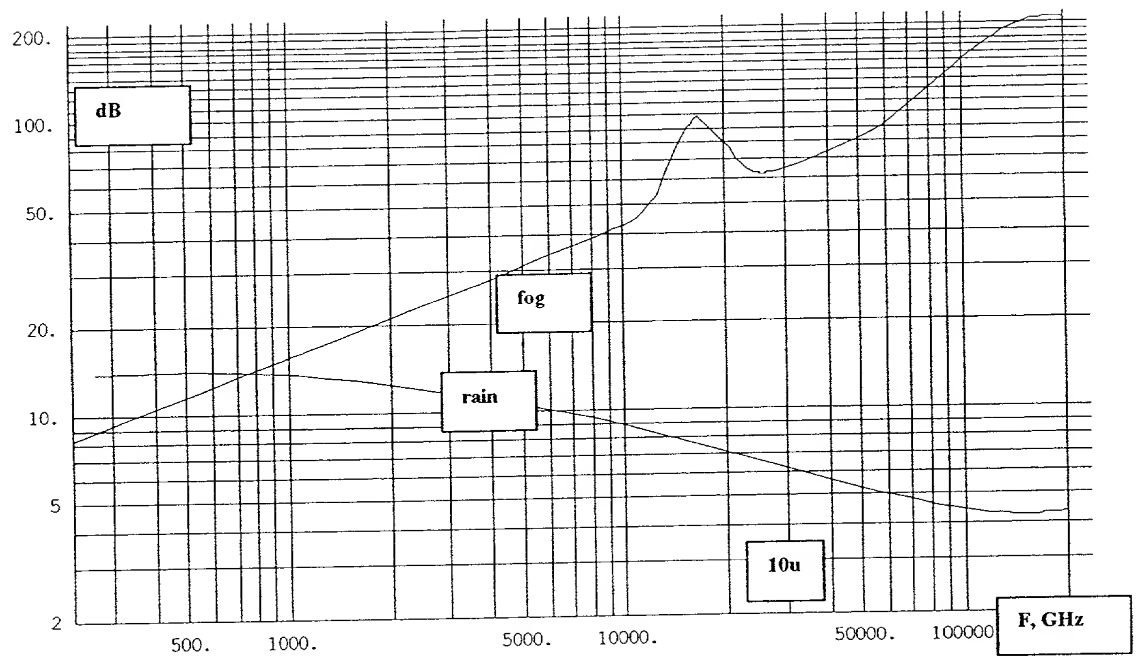

200.
100.
50.
20.
10.
5
2
dB
fog
rain
10u
500.
1000.
5000.
10000.
50000.
100000
F, GHz

Fig. 1

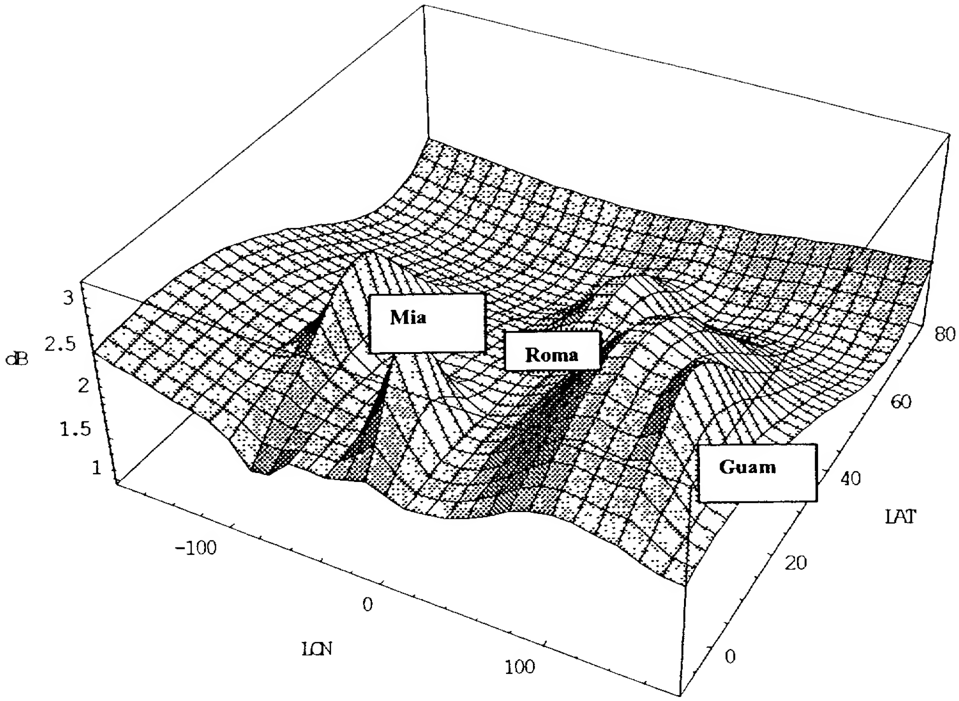

Mia
Roma
Guam
dB
3
2.5
2
1.5
1
-100
0
100
LON
80
60
40
20
0
LAT

Fig. 2

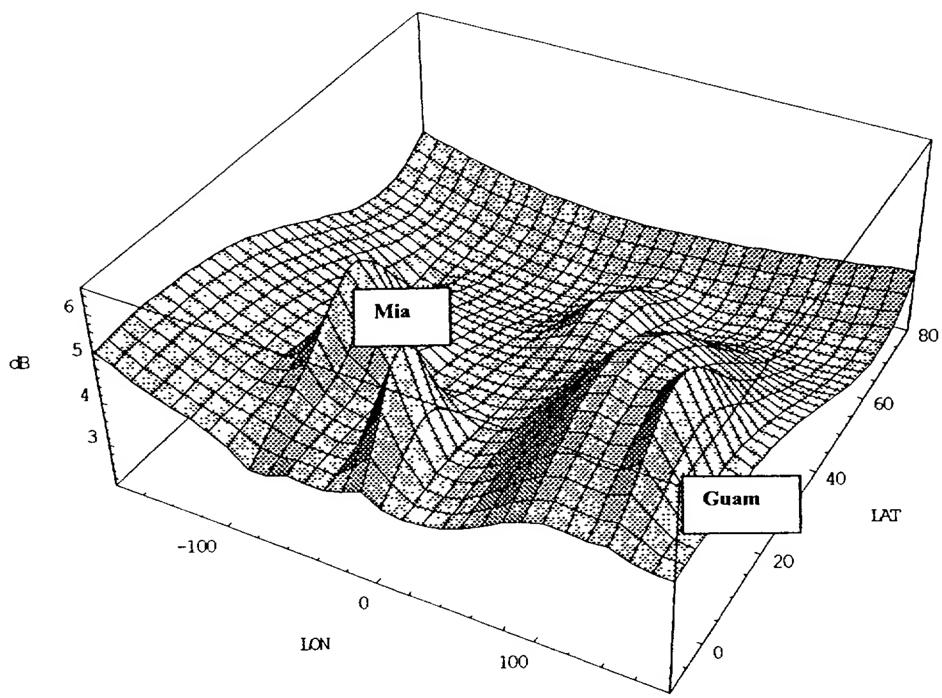

Mia
Guam
dB
6
5
4
3
-100
0
100
LON
80
60
40
20
0
LAT

Fig. 3

Short Form Global Equation for Non Rainy Zenith Attenuation (dB), For the 6-100 GHz Region; fg=Frequency, GHz

LIEBE azen=

$$0.000408122\,fg^2 \Big(5.34566 + 1.48098E^{-\frac{1}{200}(-10+LAT)^2-\frac{1}{200}(-145+LON)^2} + 2.03295E^{-\frac{1}{800}(-18+LAT)^2-\frac{(-102+LON)^2}{1800}} +$$

$$1.1968E^{-\frac{1}{200}(-52+LAT)^2-\frac{1}{800}(-28+LON)^2} - 2.78685E^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}} + 2.48024E^{-\frac{1}{72}(-2+LAT)^2-\frac{1}{200}(7+LON)^2} +$$

$$1.41803E^{-\frac{1}{50}(-20+LAT)^2-\frac{1}{200}(60+LON)^2} - 2.26449E^{-\frac{1}{200}(28+LAT)^2-\frac{1}{200}(77+LON)^2} +$$

$$1.69839E^{-\frac{1}{200}(-20+LAT)^2-\frac{1}{128}(82+LON)^2} + 0.000898808\,LAT - 0.00187405\,LAT^2 + 8.15535\times10^{-7}\,LAT^3 +$$

$$1.92203\times10^{-7}\,LAT^4 - 0.000690105\,LON - 5.83206\times10^{-6}\,LAT\,LON + 3.42574\times10^{-7}\,LAT^2\,LON +$$

$$0.0000243378\,LON^2 + 1.15354\times10^{-8}\,LATLON^2 - 3.5046\times10^{-8}\,LON^3 - 6.44437\times10^{-11}\,LON^4\Big) +$$

$$0.00586939\,fg^2 \Big(3.14686 + 0.665394E^{-\frac{1}{200}(-10+LAT)^2-\frac{1}{200}(-145+LON)^2} +$$

$$1.1188E^{-\frac{1}{800}(-18+LAT)^2-\frac{(-102+LON)^2}{1800}} + 0.716478E^{-\frac{1}{200}(-52+LAT)^2-\frac{1}{800}(-28+LON)^2} +$$

$$1.18012E^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}} + 1.21591E^{-\frac{1}{72}(-2+LAT)^2-\frac{1}{200}(7+LON)^2} - 1.89544E^{-\frac{1}{200}(28+LAT)^2-\frac{1}{200}(77+LON)^2} +$$

$$0.8941E^{-\frac{1}{200}(-20+LAT)^2-\frac{1}{128}(82+LON)^2} + 0.00101461\,LAT - 0.000943554\,LAT^2 + 2.75301\times10^{-7}\,LAT^3 +$$

$$1.00142\times10^{-7}\,LAT^4 - 0.000268921\,LON - 1.63982\times10^{-6}\,LATLON + 2.33496\times10^{-7}\,LAT^2\,LON +$$

$$0.0000108872\,LON^2 + 1.02349\times10^{-8}\,LATLON^2 - 1.77808\times10^{-8}\,LON^3 - 1.11299\times10^{-10}\,LON^4 -$$

$$0.201139\Big(5.34566 + 1.48098E^{-\frac{1}{200}(-10+LAT)^2-\frac{1}{200}(-145+LON)^2} + 2.03295E^{-\frac{1}{800}(-18+LAT)^2-\frac{(-102+LON)^2}{1800}} +$$

$$1.1968E^{-\frac{1}{200}(-52+LAT)^2-\frac{1}{800}(-28+LON)^2} - 2.78685E^{-\frac{LAT^2}{1800}-\frac{LON^2}{180000}} + 2.48024E^{-\frac{1}{72}(-2+LAT)^2-\frac{1}{200}(7+LON)^2} +$$

$$1.41803E^{-\frac{1}{50}(-20+LAT)^2-\frac{1}{200}(60+LON)^2} - 2.26449E^{-\frac{1}{200}(28+LAT)^2-\frac{1}{200}(77+LON)^2} +$$

$$1.69839E^{-\frac{1}{200}(-20+LAT)^2-\frac{1}{128}(82+LON)^2} + 0.000898808\,LAT - 0.00187405\,LAT^2 + 8.15535\times10^{-7}\,LAT^3 +$$

$$1.92203\times10^{-7}\,LAT^4 - 0.000690105\,LON - 5.83206\times10^{-6}\,LAT\,LON + 3.42574\times10^{-7}\,LAT^2\,LON +$$

$$0.0000243378\,LON^2 + 1.15354\times10^{-8}\,LATLON^2 - 3.5046\times10^{-8}\,LON^3 - 6.44437\times10^{-11}\,LON^4\Big)\Big)$$

$$\Big(0.665418 - 132.118\,(-0.740741 + 0.0333667\,fg)^2$$

$$\Big(0.999375 - 11.4943\sqrt{(-0.740741 + 0.0333667\,fg)^2}\ \mathrm{ArcTan}\Big[\frac{0.0869456}{\sqrt{(-0.740741 + 0.0333667\,fg)^2}}\Big]\Big) -$$

$$132.118\,(0.740741 + 0.0333667\,fg)^2$$

$$\Big(0.999375 - 11.4943\sqrt{(0.740741 + 0.0333667\,fg)^2}\ \mathrm{ArcTan}\Big[\frac{0.0869456}{\sqrt{(0.740741 + 0.0333667\,fg)^2}}\Big]\Big)\Big) -$$

$$0.00392386\,fg^2\Big(18.2482\Big(\mathrm{Log}\Big[\frac{(2 - 0.0333667\,fg)^2}{0.000749822 + (2 - 0.0333667\,fg)^2}\Big] +$$

$$\mathrm{Log}\Big[\frac{(3.9599999999999999 - 0.0333667\,fg)^2}{0.000187456 + (3.9599999999999999 - 0.0333667\,fg)^2}\Big] +$$

$$\mathrm{Log}\Big[\frac{(\frac{61}{10} - 0.0333667\,fg)^2}{0.000187456 + (\frac{61}{10} - 0.0333667\,fg)^2}\Big] + \mathrm{Log}\Big[\frac{(2 + 0.0333667\,fg)^2}{0.000749822 + (2 + 0.0333667\,fg)^2}\Big] +$$

$$\mathrm{Log}\Big[\frac{(3.9599999999999999 + 0.0333667\,fg)^2}{0.000187456 + (3.9599999999999999 + 0.0333667\,fg)^2}\Big] +$$

$$\mathrm{Log}\Big[\frac{(\frac{61}{10} + 0.0333667\,fg)^2}{0.000187456 + (\frac{61}{10} + 0.0333667\,fg)^2}\Big]\Big) +$$

$$27.7778\,\mathrm{Log}\Big[\frac{0.00111334\,fg^2}{0.000323595 + 0.00111334\,fg^2}\Big]\Big)$$

Fig. 4

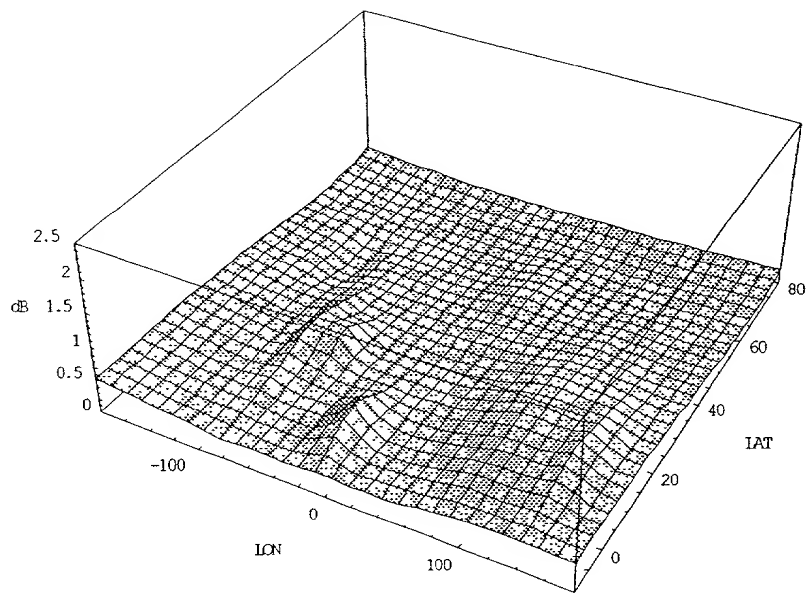

2.5
2
dB 1.5
1
0.5
0
-100
0
LON
100
80
60
40
LAT
20
0

Fig. 5

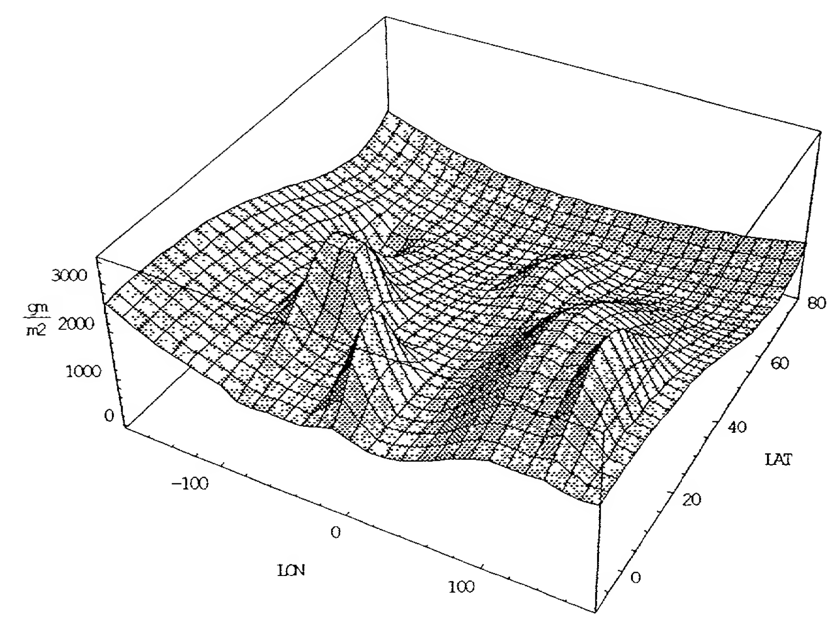

3000
gm/m2 2000
1000
0
-100
0
LON
100
80
60
40
LAT
20
0

Fig. 6

-1158.02

$$\Big(1.\Big(-0.139753\Big(1.79394 \times 10^{-7}\,LAT^4 + 8.75845 \times 10^{-7}\,LAT^3 + 3.25314 \times 10^{-7}\,LONLAT^2 - 0.00176137LAT^2 + 3.07508 \times 10^{-9}\,LON^2\,LAT - 6.69472 \times 10^{-6}\,LONLAT + 0.000919687$$

$$LAT + 1.49573e^{-\frac{1}{200}(10\ LAT)^2 - \frac{1}{200}(LON\ 145)^2} + 2.04653e^{-\frac{1}{800}(LAT\ 18)^2 - \frac{(LON\ 102)^2}{1800}} + 1.16178e^{-\frac{1}{200}(LAT-52)^2 - \frac{1}{800}(LON-28)^2} - 2.51927e^{-\frac{LAT^2}{1800} - \frac{LON^2}{180000}} +$$

$$2.46395e^{-\frac{1}{72}(LAT\ 2)^2 - \frac{1}{200}(LON-7)^2} + 1.41489e^{-\frac{1}{50}(LAT-20)^2 - \frac{1}{200}(LON-60)^2} - 2.25769e^{-\frac{1}{200}(LAT\ 28)^2 - \frac{1}{200}(LON-77)^2} + 1.69814e^{-\frac{1}{200}(LAT-20)^2 - \frac{1}{128}(LON-82)^2} +$$

$$1.07578\,e^{-\frac{1}{98}(LAT-45)^2 - \frac{1}{128}(LON-110)^2} - 4.24764 \times 10^{-11}LON^4 - 3.34843 \times 10^{-8}LON^3 + 0.0000241438LON^2 - 0.000725197LON + 3.84195\Big) +$$

$$\frac{1}{(293. - 0.25\,(LAT - 40\,))^2}\ \Big(85849.\Big(0.139753\Big(1.79394\times10^{-7}\,LAT^4 + 8.75845 \times 10^{-7}\,LAT^3 + 3\ 25314 \times 10^{-7}\,LONLAT^2 - 0.00176137LAT^2 +$$

$$3\ 07508 \times 10^{-9}\,LON^2\,LAT - 6.69472 \times 10^{-6}\,LONLAT + 0\ 000919687\ LAT + 1.49573e^{-\frac{1}{200}(10\ LAT)^2 - \frac{1}{200}(LON-145)^2} +$$

$$2.04653e^{-\frac{1}{800}(LAT-18)^2 - \frac{(LON\ 102)^2}{1800}} + 1\ 16178e^{-\frac{1}{200}(LAT-52)^2 - \frac{1}{800}(LON-28)^2} - 2.51927e^{-\frac{LAT^2}{1800} - \frac{LON^2}{180000}} + 2.46395e^{-\frac{1}{72}(LAT-2)^2 - \frac{1}{200}(LON-7)^2} +$$

$$1.41489e^{-\frac{1}{50}(LAT\ 20)^2 - \frac{1}{200}(LON-60)^2} - 2.25769e^{-\frac{1}{200}(LAT\ 28)^2 - \frac{1}{200}(LON\ 77)^2} + 1.69814e^{-\frac{1}{200}(LAT-20)^2 - \frac{1}{128}(LON\ 82)^2} +$$

$$1.07578\,e^{-\frac{1}{98}(LAT-45)^2 - \frac{1}{128}(LON\ 110)^2} - 4.24764 \times 10^{-11}LON^4 - 3.34843 \times 10^{-8}LON^3 + 0.0000241438LON^2 - 0.000725197LON + 3.84195\Big) +$$

$$1.01966\Big)\Big)$$

$$\Big(0.186801\Big(1\ 79394\times10^{-7}\,LAT^4 + 8\ 75845 \times 10^{-7}\,LAT^3 + 3\ 25314 \times 10^{-7}\,LONLAT^2 - 0.00176137LAT^2 + 3.07508 \times 10^{-9}\,LON^2\,LAT -$$

$$- 6.69472 \times 10^{-6}\,LONLAT + 0.000919687\ LAT + 1.49573e^{-\frac{1}{200}(10-LAT)^2 - \frac{1}{200}(LON\ 145)^2} + 2.04653e^{-\frac{1}{800}(LAT\ 18)^2 - \frac{(LON-102)^2}{1800}} +$$

$$1.16178e^{-\frac{1}{200}(LAT-52)^2 - \frac{1}{800}(LON\ 28)^2} - 2\ 51927e^{-\frac{LAT^2}{1800} - \frac{LON^2}{180000}} + 2.46395e^{-\frac{1}{72}(LAT\ 2)^2 - \frac{1}{200}(LON-7)^2}\ 1.41489e^{-\frac{1}{50}(LAT-20)^2 - \frac{1}{200}(LON-60)^2} -$$

$$2.25769e^{-\frac{1}{200}(LAT\ 28)^2 - \frac{1}{200}(LON\ 77)^2} + 1.69814e^{-\frac{1}{200}(LAT-20)^2 - \frac{1}{128}(LON\ 82)^2} + 1.07578\,e^{-\frac{1}{98}(LAT-45)^2 - \frac{1}{128}(LON-110)^2} -$$

$$4.24764 \times 10^{-11}LON^4 - 3.34843 \times 10^{-8}LON^3 + 0.0000241438LON^2 - 0.000725197LON + 3.84195\Big) + 0.332309\Big)\log(PR) - 0.919661\Big) -$$

$$0.764706\Big(-0.352549\Big(1.03045\times10^{-7}\,LAT^4 + 2.23192 \times 10^{-7}\,LAT^3 + 2.44557 \times 10^{-7}\,LONLAT^2 - 0.000975417LAT^2 + 1.0003 \times 10^{-8}\,LON^2\,LAT - 2.18586 \times 10^{-6}\,LONLAT +$$

$$0.00128521LAT + 0.66746e^{-\frac{1}{200}(10\ LAT)^2 - \frac{1}{200}(LON\ 145)^2} + 1.12036e^{-\frac{1}{800}(LAT-18)^2 - \frac{(LON-102)^2}{1800}} + 0.70296e^{-\frac{1}{200}(LAT-52)^2 - \frac{1}{800}(LON-28)^2} - 1.28258e^{-\frac{LAT^2}{1800} - \frac{LON^2}{180000}} +$$

$$1.22726e^{-\frac{1}{72}(LAT\ 2)^2 - \frac{1}{200}(LON-7)^2} - 1.92779e^{-\frac{1}{200}(LAT\ 28)^2 - \frac{1}{200}(LON\ 77)^2} + 0.865964e^{-\frac{1}{200}(LAT-20)^2 - \frac{1}{128}(LON-82)^2} -$$

$$0.0909198\,e^{-\frac{1}{98}(LAT-45)^2 - \frac{1}{128}(LON-110)^2} - 1.36816 \times 10^{-10}LON^4 - 1.38211 \times 10^{-8}LON^3 + 0.000011497LON^2 - 0.000416968LON + 2.53967\Big) +$$

$$\Big(0.140592\Big(1.03045\times10^{-7}\,LAT^4 + 2.23192 \times 10^{-7}\,LAT^3 + 2.44557 \times 10^{-7}\,LONLAT^2 - 0\ 000975417LAT^2 + 1.0003 \times 10^{-8}\,LON^2\,LAT -$$

$$2.18586 \times 10^{-6}\ LONLAT + 0\ 00128521LAT + 0.66746e^{-\frac{1}{200}(10\ LAT)^2 - \frac{1}{200}(LON-145)^2} + 1\ 12036e^{-\frac{1}{800}(LAT-18)^2 - \frac{(LON\ 102)^2}{1800}} + 0.70296e^{-\frac{1}{200}(LAT\ 52)^2 - \frac{1}{800}(LON-}$$

$$- 1.28258e^{-\frac{LAT^2}{1800} - \frac{LON^2}{180000}} + 1.22726e^{-\frac{1}{72}(LAT-2)^2 - \frac{1}{200}(LON\ 7)^2} - 1.92779e^{-\frac{1}{200}(LAT\ 28)^2 - \frac{1}{200}(LON-77)^2} + 0.865964e^{-\frac{1}{200}(LAT-20)^2 - \frac{1}{128}(LON-82)^2} -$$

$$0.0909198\,e^{-\frac{1}{98}(LAT-45)^2 - \frac{1}{128}(LON\ 110)^2} - 1.36816 \times 10^{-10}LON^4 - 1.38211 \times 10^{-8}LON^3 + 0.000011497LON^2 - 0.000416968LON + 2.53967\Big) +$$

$$0.132924\Big)\log(PR) - 0.0878644\Big)\Big)$$

Fig. 7

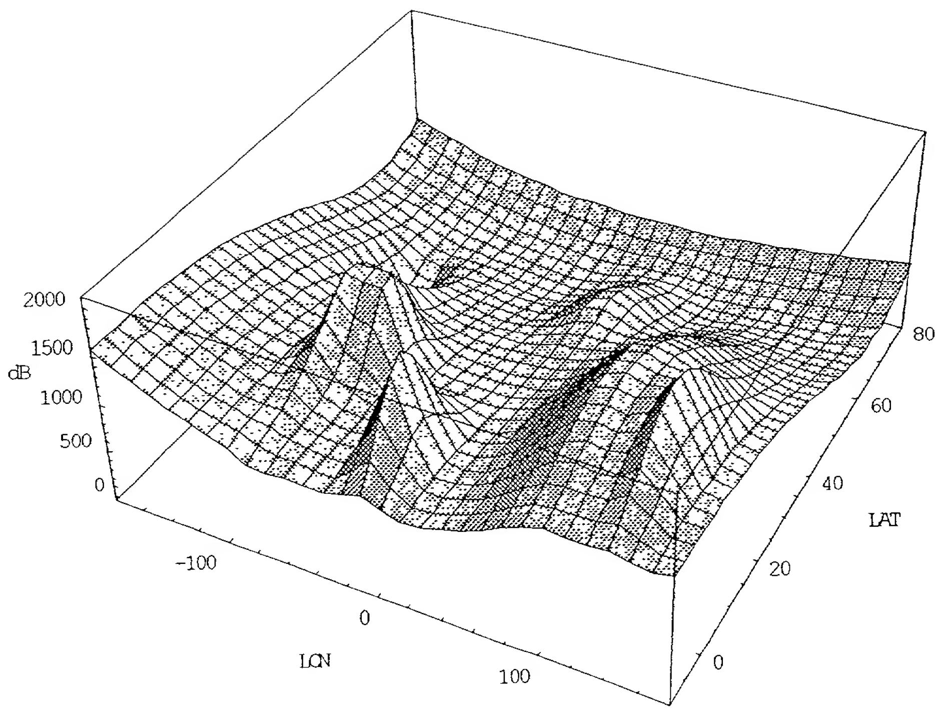


Fig. 8

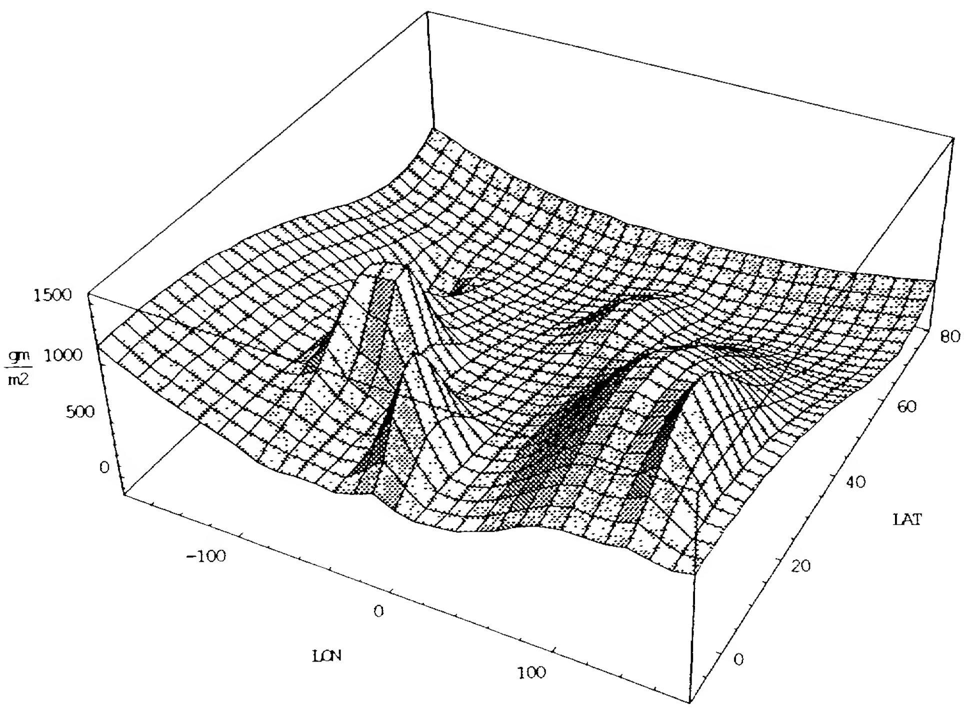


Fig. 9

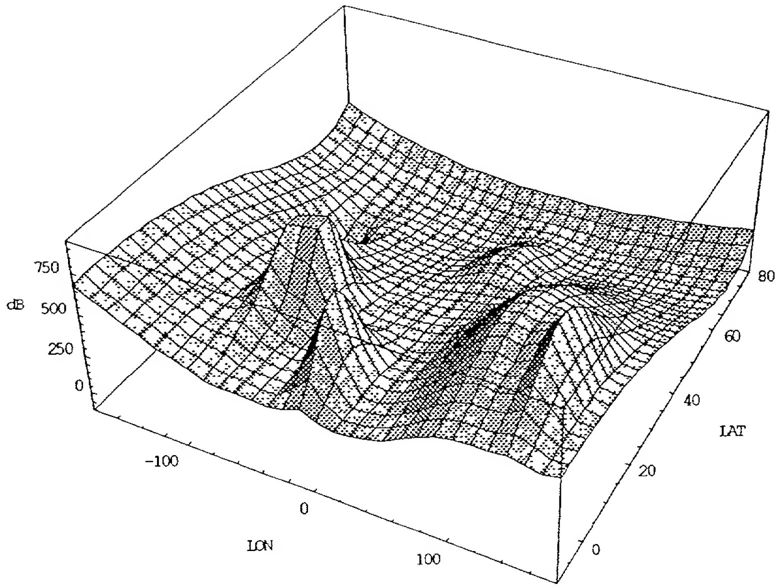

750
dB
500
250
0
-100
0
LON
100
80
60
40
LAT
20
0

Fig. 10

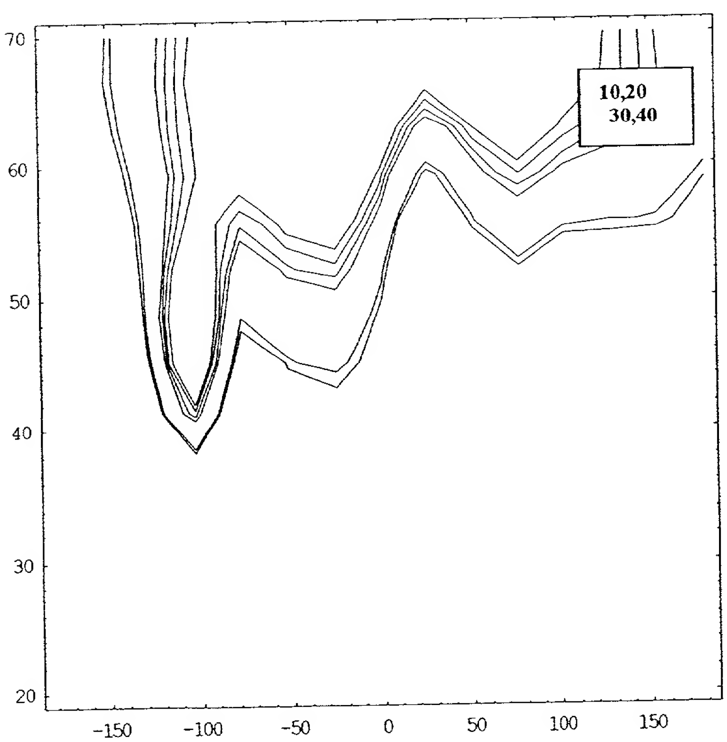
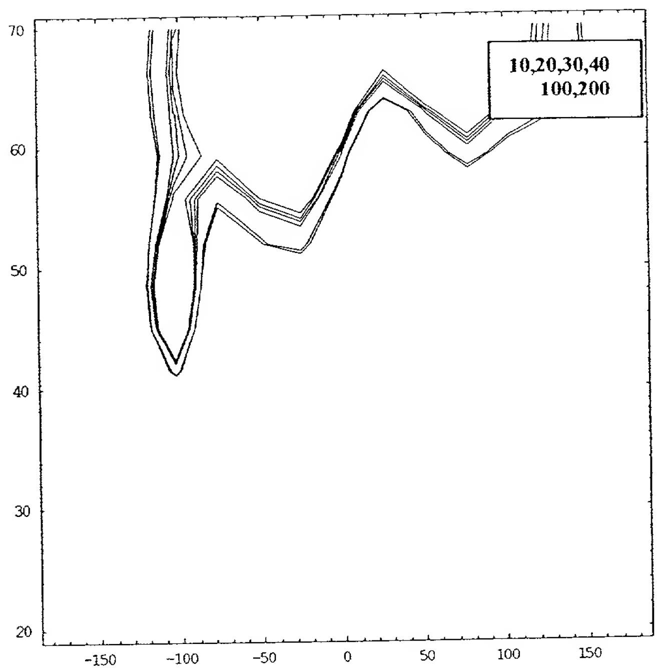
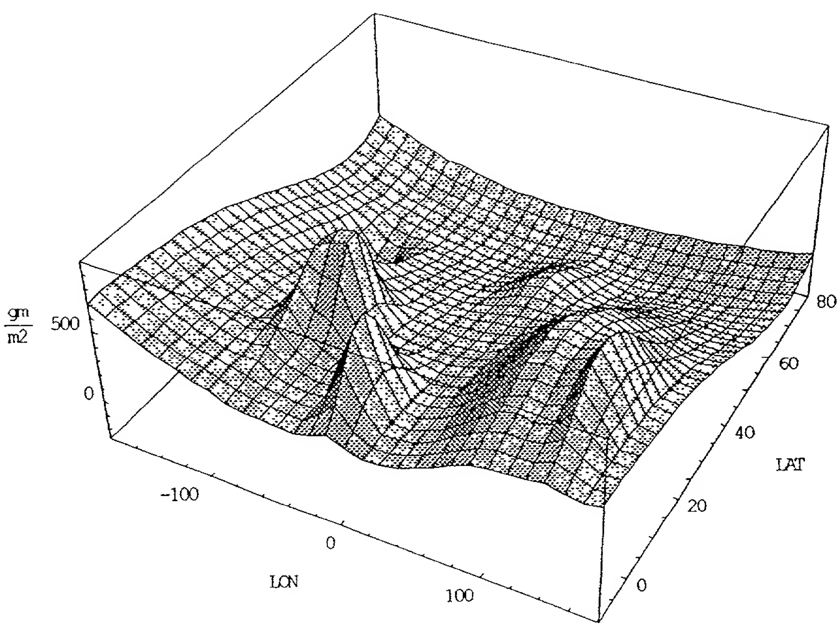

70
60
50
40
30
20
-150
-100
-50
0
50
100
150
10,20
30,40

Fig. 11



10,20,30,40
100,200
70
60
50
40
30
20
-150
-100
-50
0
50
100
150

Fig. 12



gm
m2
500
0
-100
0
LON
100
0
20
40
60
80
LAT

Fig. 13

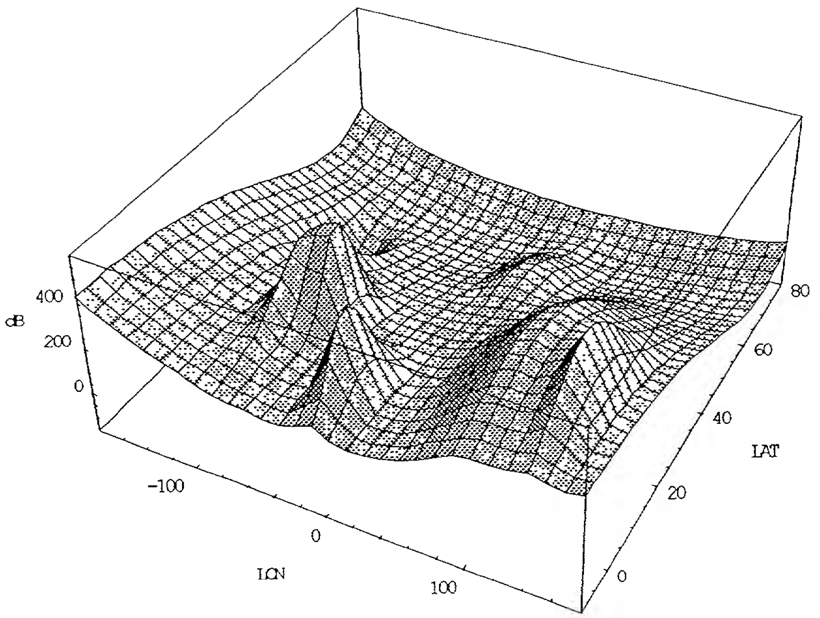

dB
400
200
0
-100
0
LON
100
80
60
40
LAT
20
0

Fig. 14

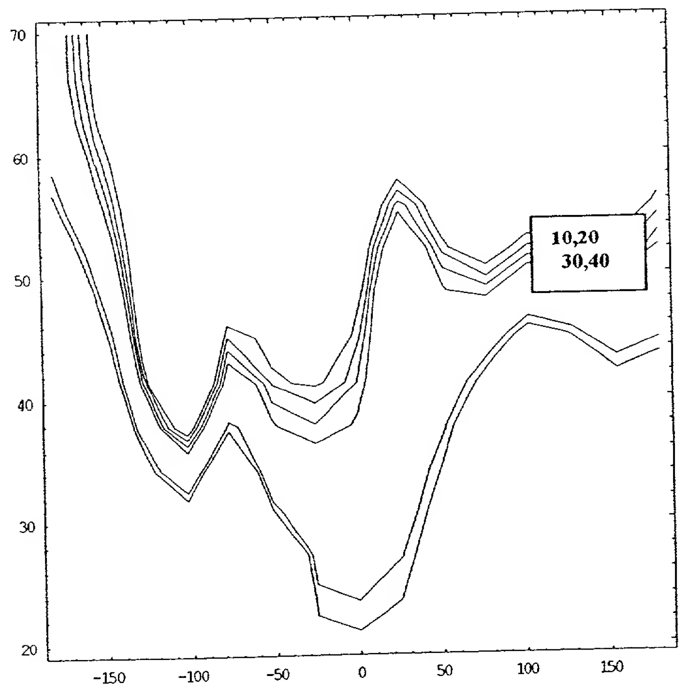

70
60
50
40
30
20
10,20
30,40
-150
-100
-50
0
50
100
150

Fig. 15

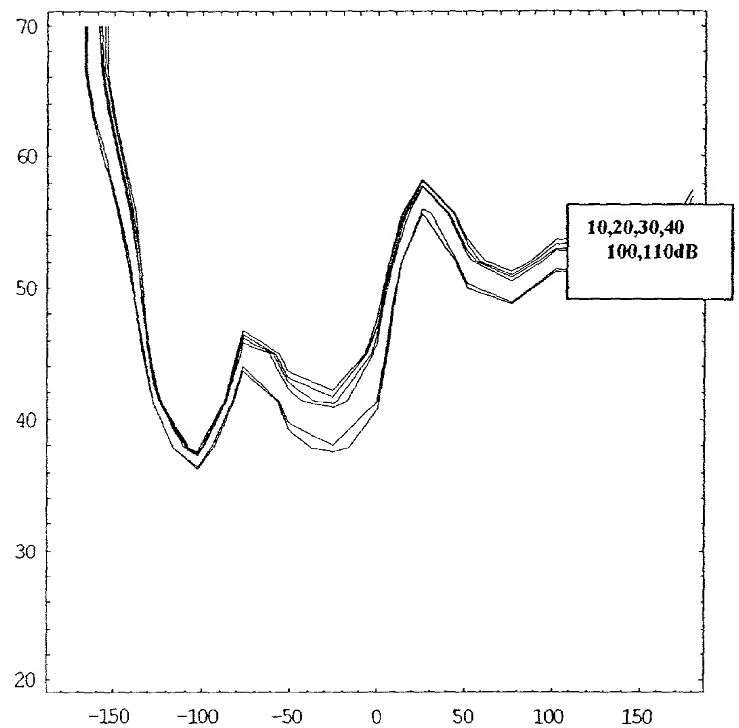


Fig. 16

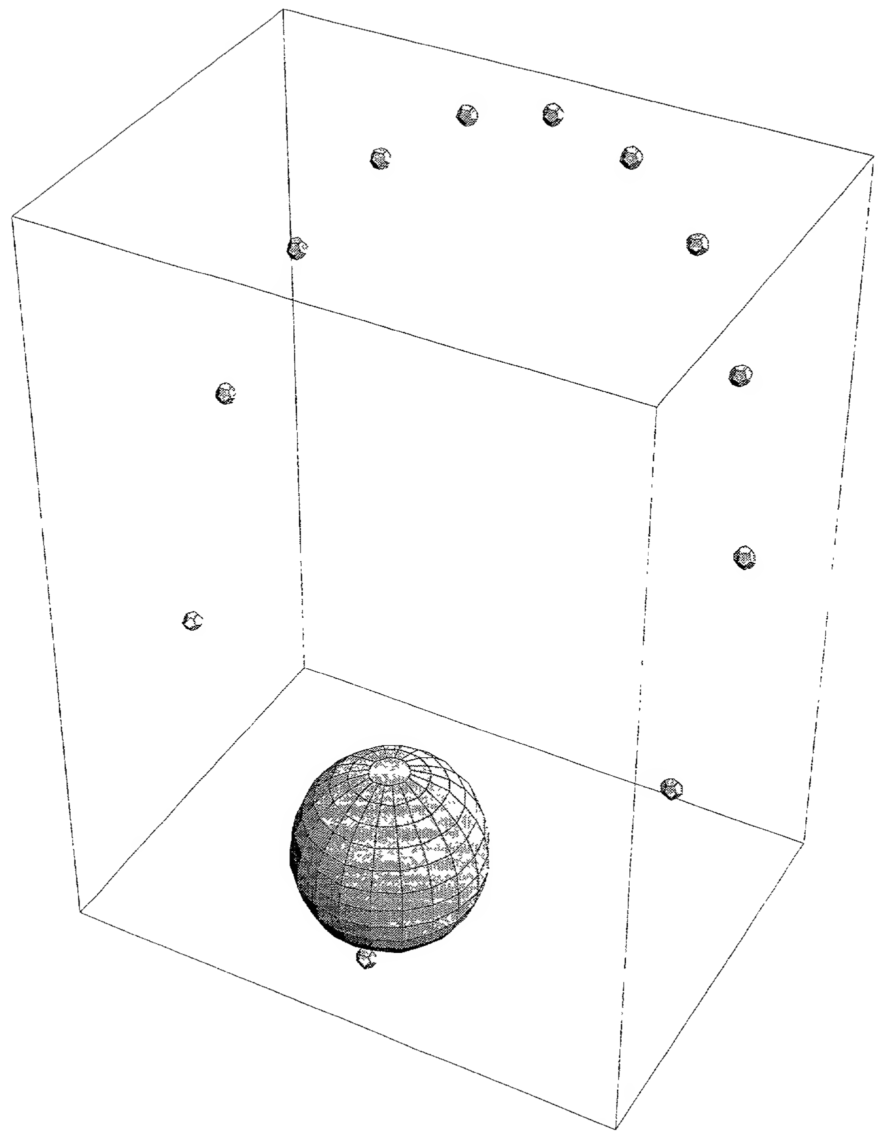


Fig. 17

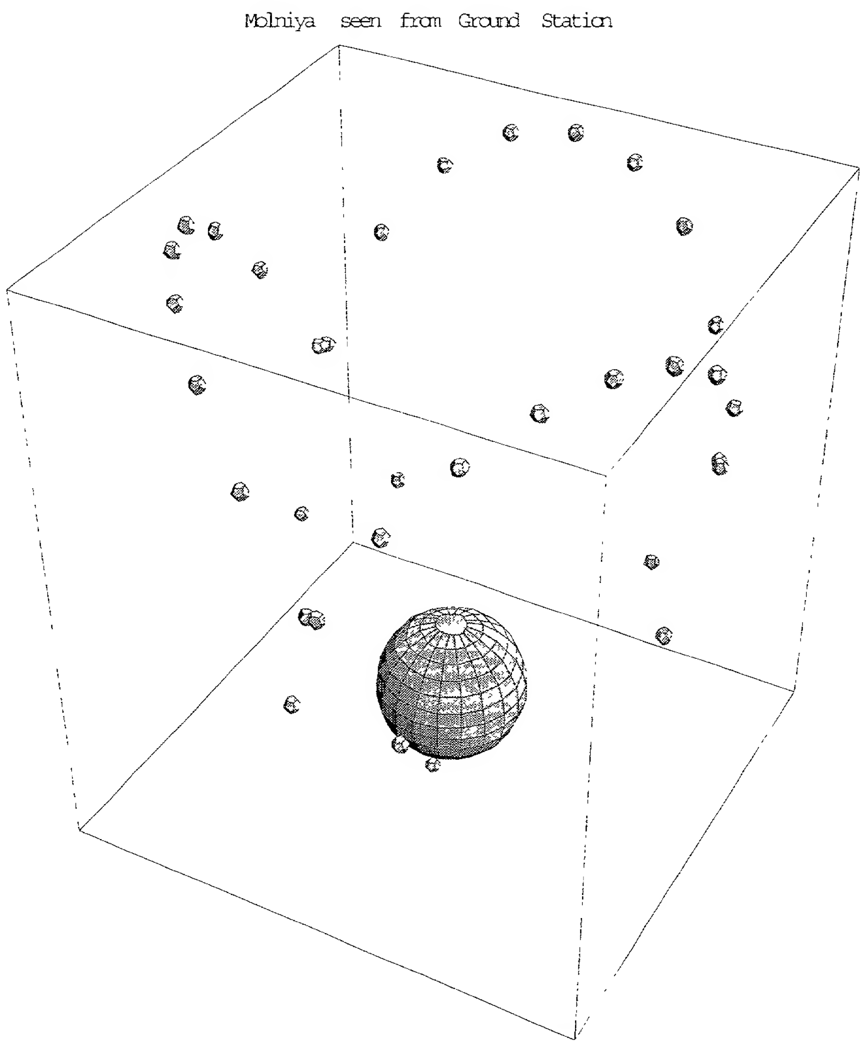


Fig. 18

MolniyaGEO pdf=

$$\frac{e^{-\frac{\left(5.22822\times 10^{-6}\,LAT^4-0.000520006\,LAT^3+0.00512491\,LAT^2+0.165865\,LAT+x-47.0509\right)^2}{2\left(0.00029238\,LAT^4-0.00526509\,LAT^3+0.270942\,LAT^2-0.776901\,LAT+181.722\,e^{-\frac{LAT^2}{900}}-160.041\right)^2}}}{\left(0.00029238\,LAT^4-0.00526509\,LAT^3+0.270942\,LAT^2-0.776901\,LAT+181.722\,e^{-\frac{LAT^2}{900}}-160.041\right)\sqrt{2\pi}}$$

With x representing elevation angle in degrees

Fig. 19

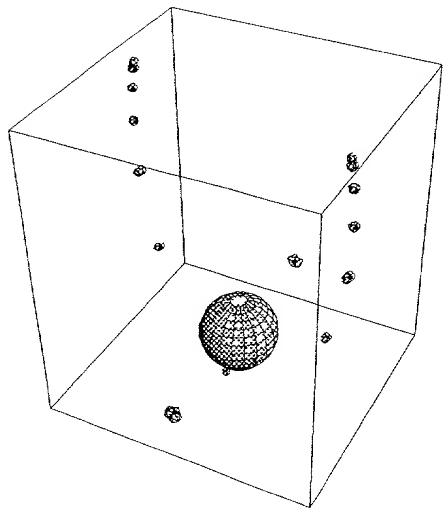


Fig. 20

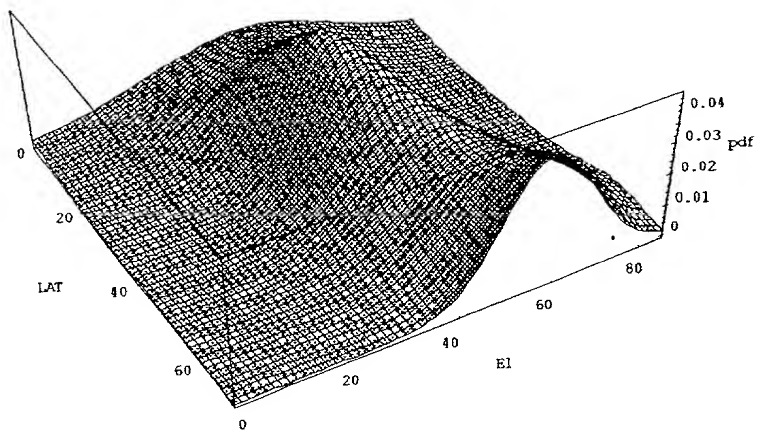


Fig. 21

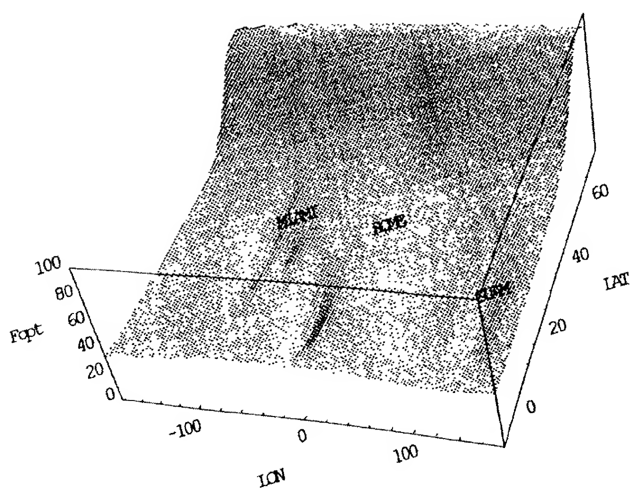


Fig. 22

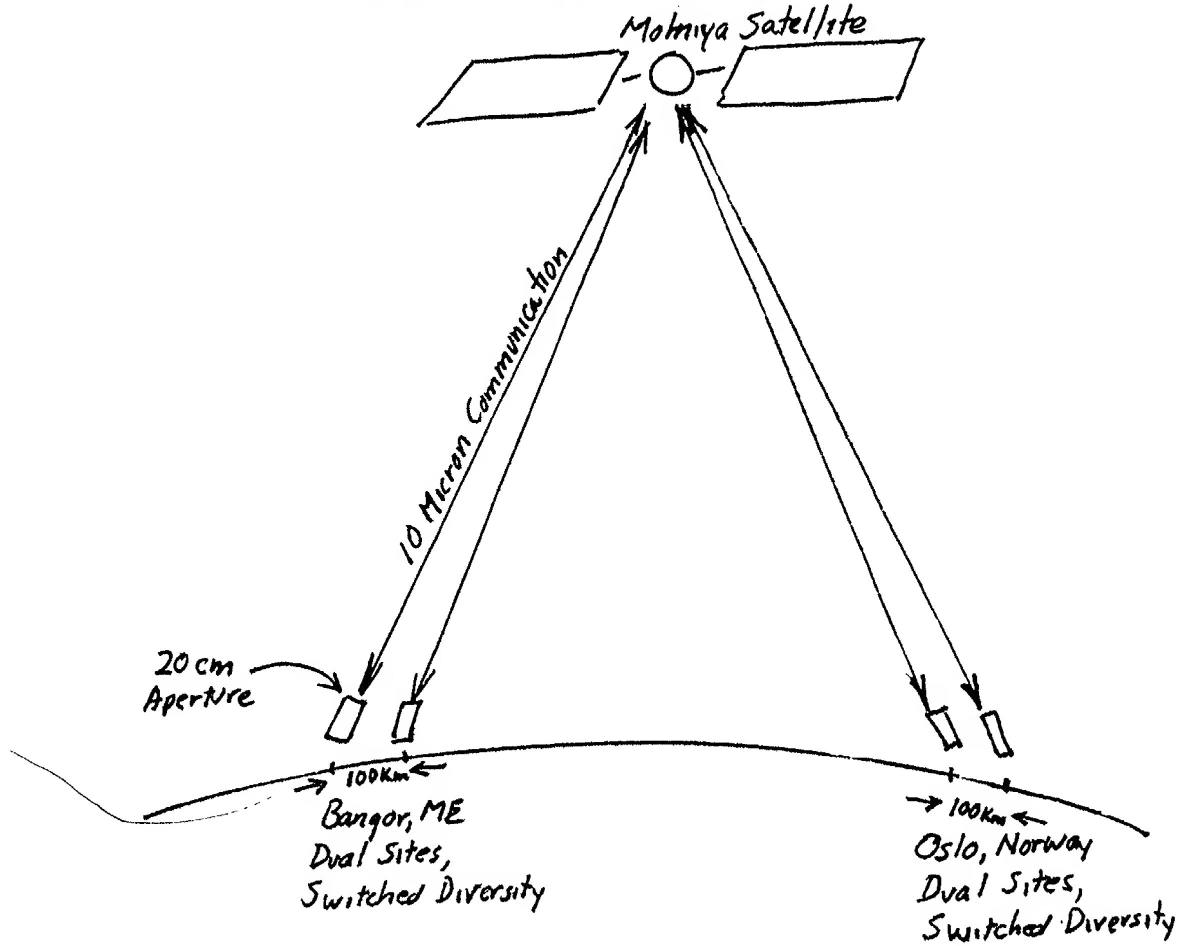

Molniya Satellite
10 Micron Communication
20 cm
Aperture
100Km
Bangor, ME
Dual Sites,
Switched Diversity
100Km
Oslo, Norway
Dual Sites,
Switched Diversity

Fig. 23

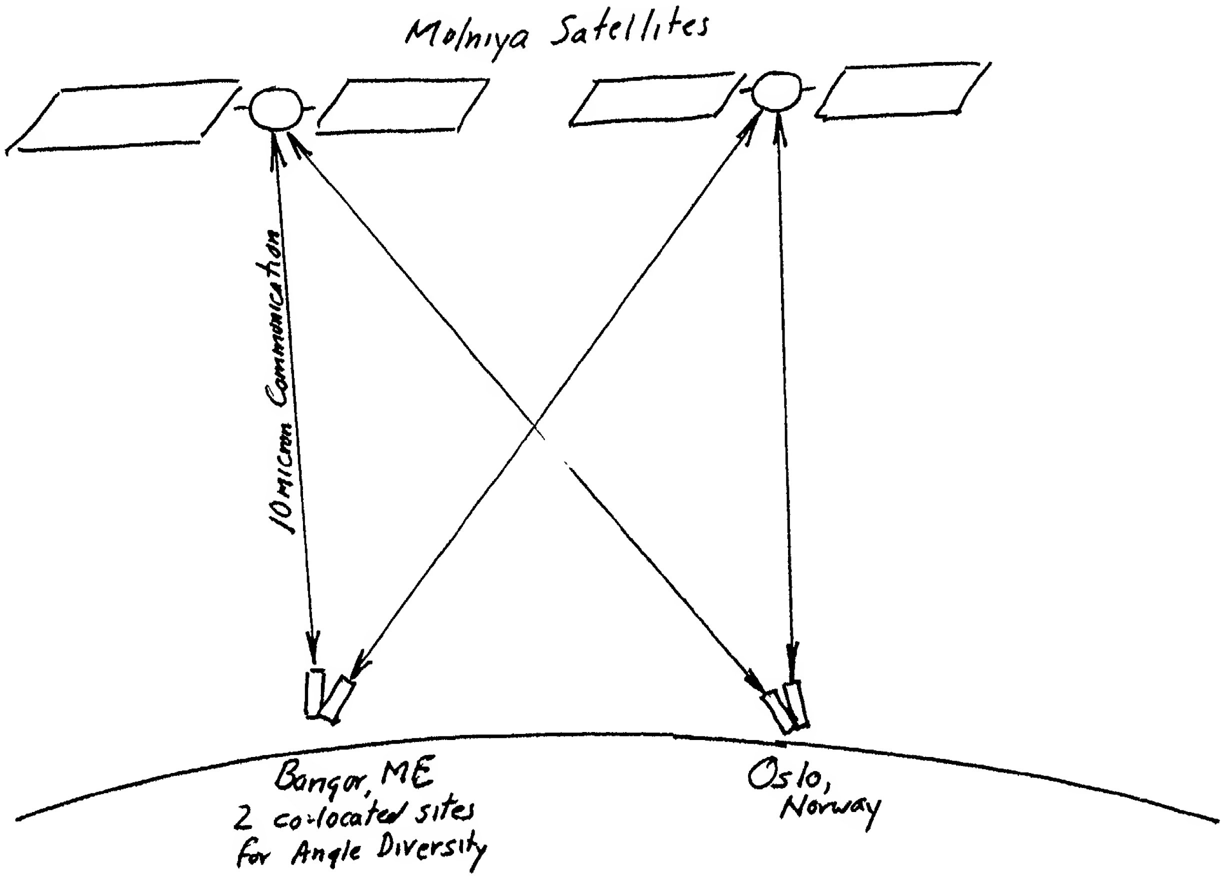

Molniya Satellites
10 micron Communication
Bangor, ME
2 co-located sites
for Angle Diversity
Oslo,
Norway

Fig. 24